

Appendix 4**Line termination**

The line is usually terminated by a resistance R in series with a capacitor C, which is paralleled by the loop resistance and capacitors. To determine the termination is to identify all these parameters. In Appendix 1 and 2 we have got the equivalent impedance Z or admittance of the termination Y at two frequencies when we identify the model parameters. We now considering using admittance representation. From Figure 9 we have

$$Y = g + j\omega c_1 + \frac{j\omega c_2}{1 + j\omega R c_2} \quad (1)$$

Let

$$Y = a + jb \quad (2)$$

where a and b are the real and imaginary part of Y respectively. So

$$a = g + \frac{\omega^2 R c_2^2}{1 + \omega^2 R^2 c_2^2} \quad (3)$$

$$b = \omega c_1 + \frac{\omega c_2}{1 + \omega^2 R^2 c_2^2} \quad (4)$$

Let

$$R c_2 = x \quad (5)$$

and measure the Y at two frequencies ω_1 and ω_2 , we have

$$a_1 - a_2 = \frac{\omega_1^2 x c_2}{1 + \omega_1^2 x^2} - \frac{\omega_2^2 x c_2}{1 + \omega_2^2 x^2} \quad (6)$$

and

$$\frac{b_1}{\omega_1} - \frac{b_2}{\omega_2} = \frac{c_2}{1 + \omega_1^2 x^2} - \frac{c_2}{1 + \omega_2^2 x^2} \quad (7)$$

(6)/(7) we have

$$\begin{aligned}
 \frac{a_1 - a_2}{\frac{b_1}{\omega_1} - \frac{b_2}{\omega_2}} &= \frac{\frac{\omega_1^2 x}{1 + \omega_1^2 x^2} - \frac{\omega_2^2 x}{1 + \omega_2^2 x^2}}{\frac{1}{1 + \omega_1^2 x^2} - \frac{1}{1 + \omega_2^2 x^2}} \\
 &= x \frac{\omega_1^2(1 + \omega_2^2 x^2) - \omega_2^2(1 + \omega_1^2 x^2)}{(1 + \omega_2^2 x^2) - (1 + \omega_1^2 x^2)} \\
 &= x \frac{\omega_1^2 - \omega_2^2}{\omega_2^2 x^2 - \omega_1^2 x^2} \\
 &= -\frac{1}{x}
 \end{aligned} \tag{8}$$

i.e.

$$x = -\frac{\frac{b_1}{\omega_1} - \frac{b_2}{\omega_2}}{a_1 - a_2} = \frac{1}{\omega_1 \omega_2} \frac{\omega_2 b_1 - \omega_1 b_2}{a_2 - a_1} \tag{9}$$

After we get x, c_2 can be calculated from (6), which gives

$$c_2 = \frac{(a_1 - a_2)(1 + \omega_1^2 x^2)(1 + \omega_2^2 x^2)}{x(\omega_1^2 - \omega_2^2)} \tag{10}$$

and R from (5)

$$R = \frac{x}{c_2} \tag{11}$$

So g and c_1 can be determined from (3) and (4) respectively

$$g = a_1 - \frac{\omega_1^2 x c_2^2}{1 + \omega_1^2 x^2} \tag{12}$$

and

$$c_1 = \frac{b_1}{\omega_1} - \frac{c_2}{1 + \omega_1^2 x^2} \tag{13}$$